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Methodological aspects of the evaluation of local climate changes

Aspekty metodyczne związane z ocena lokalnych zmian klimatu

To understand climatic transformations caused by land use changes one needs to look into the annual and long-term pattems of individual climate factors. This paper presents the spatial differentiation of thermal conditions in the Wieliczka Foothills (Carpathian Foreland), and particularly in the Raba river valley after the erection of the Dobczyce water dam. It also discusses the scope for the changes of active surface and matter circulation in the environment.

The research employs thermographic data recorded during 1971-1996 in Gaik-Brzezowa at the Research Station of the Institute of Geography and Spatial Management, Jagiellonian University of Cracow, and representing the Raba valley bed (Terrace 259 m a.s.l.), its slopes (Slope 283 m) and the summit plain Mound (302 m a.s.l.) in the Wieliczka Foothills. Taking into account the significance of the woodland for water circulation in this part of the Carpathian Mts., the project also took into account the thermal conditions of the *Tilio-Carpinetum* forest in the foothills (Forest 282 m a.s.l.). Selected stations were located close to each other and were subject to regional climatic changes related to the solar factors (external in the climatic system), air circulation and local environmental influences such as ground relief, hydrology, plant life and land use forms. Particular attention was paid to the stability of the thermal conditions in the *Tilio-Carpinetum* forest and to changes in the topoclimatic structure caused by the opening in 1987 of the medium-sized artificial water reservoir,

a source of drinking water for Cracow_The paper shows the results of the analysis of mean annual air temperature in the Raba valley in 1971-1984 and 1988-1996 representing spatial pattem of air temperature before and after the opening of the water reservoir. The temperature was measured at the standard height of 2 m above the ground level. The research confirmed a grater usefulness of the extreme temperature values for the understanding of the transformation of the thermal condition panem. Alongside the year-to-year variability of those characteristics, the five-year moving mean values showed some interesting tendencies. During the research period, insolation in the Gaik-Brzezowa station and in Cracow displayed a permanent tendency to drop, beginning in 1950 with the smallest yearly sum of sunshine duration in 1980. Atmospheric circulation was characterised by a steadily growing domination of high pressure over low-pressure systems_ Generally, there were two fluctuations in the long-term temperature pattern: cool (1971-1987) and warm (1988-1996), which coincided with the phases of anthropopression mentioned above.

Table 1 shows the selected characteristics of air temperature and standard deviations during these two phases. The data indicates that between 1971 and 1984, the foothill stretch of the Raba valley bad thermal conditions typical for concave land forms, dependent on frequent occurrence of strong air temperature stratification. During 1988-1996, the internal valley circulation wakened as a result of the reduction in the relative altitude of the surrounding summit plains above the new reservoir water level (Obrębska-Starkel, Grzyborowska 2000), the changed thermal capacity of the ground and the new domination of advective factors.

The long-term sequence of the basie thermal characteristics allows further conclusions regarding the transformation of climatic conditions of the Wieliczka Foothills in the lower part of the moderate warm climatic vertical zone at the end of the 20th century. One should remember that the researched topoclimatic sites were located close together. The annual average air temperature changed from year to year in a very irregular way with the highest values recorded in 1983, 1989, 1992 and 1994 (Fig. 1). The 1983 average was the result of all seasons but the fall, while the high average temperature in 1989 was the result of the average temperature of the spring and autumn; 1984 was warm throughout. The coldest years included 1996 with the average temperature of winter, spring and summer much lower than the average and 1980 with all seasons colder than the average (Obrębska-Starkel 2000, at the publisher). The average air temperature amplitude both annual (Fig. 2) and seasonal (Fig. 3), varied in a broad range through 1971-1996. However, it included certain individual features, such as the significant reduction in the autumn amplitude from mid-1980s onwards. This could mean that the mass of water in the new reservoir influenced the energy balance of the surrounding area by dampening the sharp turns of this characteristic from year to year.

Tab. I. Yearly and seasonal mean and extreme values of air temperature (in °C) and their standard deviations (6) in the periods: a) 1971-1984; b) 1988-1996 (Obrębska-Starkel, Grzyborowska 2000)

Średnie i ekstremalne wartości temperatury powietrza (w °C) w roku, standardowych porach roku oraz odchylenia standardowe (6): a) w latach 1971-1984, b) w latach 1988-1996 (Obrębska-Starkel, Grzyborowska 2000)

Station	Season	Tean	6	Tmeanmax	6	Tmeanmin.	6
a)							
1	year	7.6	8.4	12.5	9.1	3.1	7.5
2		8.3	8.0	12.3	9.0	4.1	7.4
3		7.8	7.8	11.6	8.5	4.0	7.4
1	winter XII 1970-II 1984	-1.1	5.2	2.5	5.1	-4.9	6.3
2		-0.9	5.0	2.0	5.0	-3.9	5.6
3		-I.O	5.1	2.0	5.0	-4.1	5.8
1	spring	7.6	5.6	12.8	6.8	2.4	5.0
2		8.2	5.6	12.6	6.8	3.5	5.0
3		7.9	5.6	12.4	6.6	3.2	5.2
1	summer	16.2	3.6	21.8	4.4	10.9	2.8
2		16.8	3.2	21.5	4.3	11.7	2.9
3		16.0	3.0	20.0	4.0	11.8	2.8
1	autumn	7.8	7.6	12.7	7.0	3.9	5.2
2		8.7	5.8	12.5	6.9	4.9	5.2
3		8.3	5.6	11.8	6.3	4.8	5.3
b)							
4	year	8.6	8.2	12.7	9.2	4.6	7.5
2		9.0	8.2	13.2	9.3	4.8	7.5
3		8.6	8.0	12.1	8.6	4.7	7.5
4	winter	-O.I	5.7	2.9	5.8	-3.2	6.0
2		0.0	5.8	3.1	5.9	-3.1	6.1
3		-0.1	5.6	2.7	5.8	-3.3	6.0
4	spring	8.1	5.8	12.6	6.8	3.6	5.1
2		8.6	5.7	13.3	6.7	3.7	5.0
3		8.2	5.6	12.5	6.6	3.6	5.2
4	summer	17.5	3.4	22.6	4.6	12.8	2.8
2		18.0	3.4	23.0	4.5	12.7	2.8
3		17.2	3.2	21.1	4.1	12.8	2.8
4	autumn	8.6	5.9	12.3	6.9	5.2	5.6
2		9.0	6.0	12.7	7.0	5.3	5.5
3		8.6	5.8	11.7	6.3	5.3	5.6

1 - Terrace, 2 - Slope, 3 - Forest, 4 - MoWld.

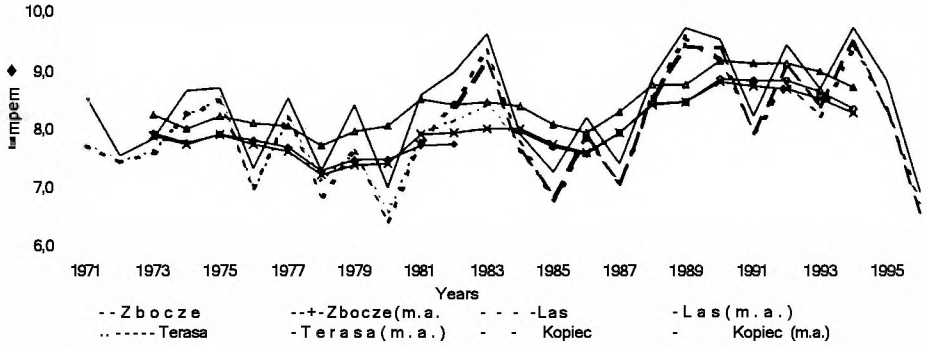

Fig. 1. Mean annual values of the air temperature (in °C) and the 5-year moving averages (m.a.) at the sites: Slope (Zbocze), Forest (Las) in the period 1971-1996, Terrace (Terasa) 1971-1984 and Mound (Kopiec) 1983-1996

Średnia temperatura roku (w °C} i pięcioletnie średnie konsekutywne (m.a.) na stanowiskach: Zbocze, Las w okresie 1971-1996, Terasa 1971-1984 i Kopiec 1983-1996

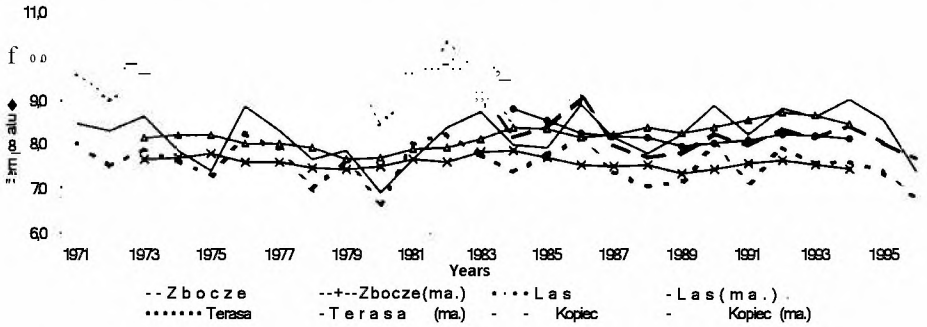

Fig. 2. Mean annual values of the air temperature range (in °C) and the 5-year moving averages (m.a.) at the sites: Slope (Zbocze), Forest (Las) in the period 1971-1996, Terrace (Terasa) 1971-1984 and Mound (Kopiec) 1983-1996

Średnie wartości amplitudy temperatury powietrza (w °C} i pięcioletnie średnie konsekutywne (m.a.) na stanowiskach: Zbocze, Las w okresie 1971-1996, Terasa 1971-1984 i Kopiec 1983-1996

Charts showing the long-term air temperature characteristic on all topoclimatic sites in the vicinity of the Dobczyce Water reservoir make easier the determination of the moment when humans started influencing the local geographical environment. Such research results could have been bener documented if it bad not been for the advancing reduction in the weather stations network, which could otherwise have provided a benchmark for the evaluation of data homogeneity. In order to facilitate different scales of research into the variability and change of climate the metadata should also include information of the changes in the land use. Any change to the form of the human economy in the

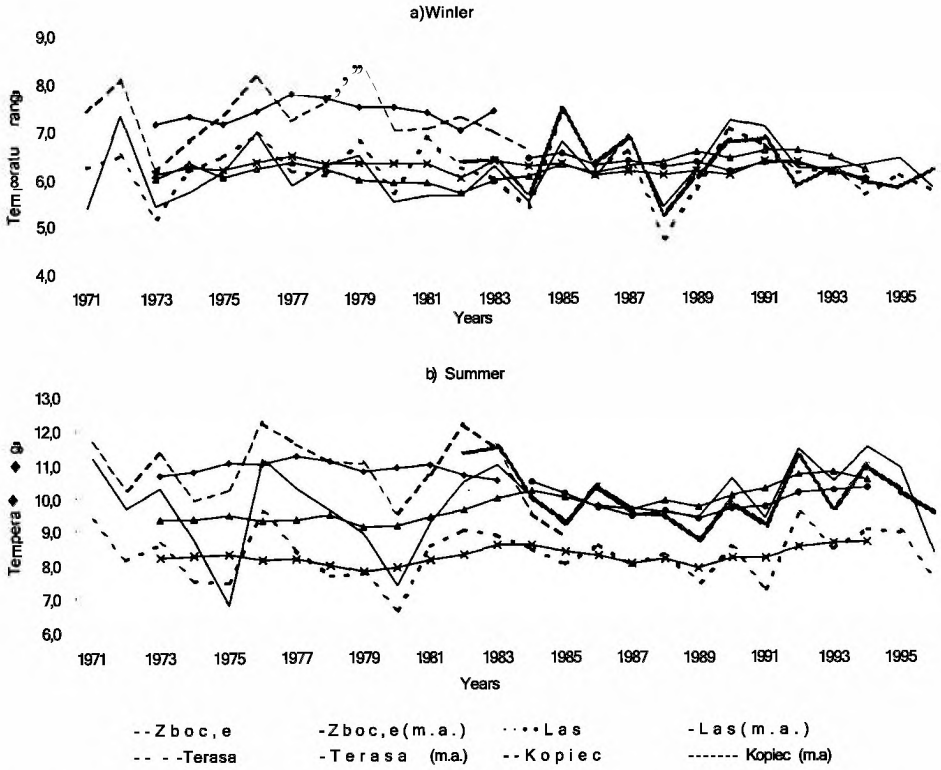

Fig. 3. Mean values of the air temperature range (in °C) and the 5-year moving averages (m.a.) in seasons: a) winter, b) swnmer, at the sites: Slope (Zbocze), Forest (Las) in the period 1971-1996, Terrace (Terasa) 1971-1984 and Mound (Kopiec) 1983-1996
Średnie wartości amplitudy temperatury powietrza (w °C) i pięcioletnie średnie konsekutywne (m.a.) w porach roku: a) zima, b) lato, na stanowiskach: Zbocze, Las w okresie 1971-1996, Terasa 1971-1984 i Kopiec 1983-1996

environment causes an impact on the matter and energy cycle and overlap in different ways with the natura} climatic condition change. Omitting these relationships may lead to errors in the conclusions on the functioning of the environment and to wrong decisions on the use of natural resources.

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REFERENCES

Obrębska-Starkel B. 2000; Influence of the water reservoir on the transfonnation of the ecoclimate of the foothill oak-hombeam forest *Tilio-Carpinetum* in Gaik-Brzezowa. [In:] Topoclimatic and geoecological changes in the Wieliczka foothills in the surroundings of the Dobczyce reservoir. B. Obrębska-Starkel (ed.), manuscript.

Obrębska-Starkel B., Grzyborowska A. 2000; Symptomy współczesnego przekształcania ekoklimatu grądu pogórskiego *Tilio-Carpinetum* w Gaiku-Brzezowej. Folia Geogr., Geogr.-Physica (in print).

STRESZCZENIE

Opracowanie zostało poświęcone ocenie zmian warunków topoklimatycznych na skutek przeobrażeń stosunków antropogenicznych w warunkach rzeźby pogórskiej Karpat, spowodowanych wybudowaniem zbiornika wodnego w Dobczycach. Badania zostały oparte na serii codziennych danych termograficznych z lat 1971-1996 z czterech stanowisk: Terasa (259 m n.p.m.), Zbocze (283 m), Las (282 m) i Kopiec (302 m). Celem określenia zachodzących przekształceń pod wpływem zmian w użytkowaniu ziemi badano w przebiegu wieloletnim średnie roczne wartości temperatury powietrza, odpowiednie średnie sezonowe i średnie ekstrema dla tych samych przedziałów czasowych. Wpływ czynników lokalnych, a w tym antropopresji (budowa zbiornika wodnego) przekraczał udział klimatotwórczych czynników solarnych i cyrkulacji atmosferycznej w mezoskali. Autorki postulują, aby badania zmian klimatu i zmienności topoklimatu w skali lokalnej były oparte na wieloletnich seriach pomiarowych, pozwalających na przeprowadzenie analizy trendów dla wybranych elementów klimatu. Natomiast zbiory meta-data winny być uzupełnione o dokładną informację na temat sposobów użytkowania ziemi i ich przemian.